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~~AEC ATOMIC WEAPON DATA~~
~~Sigma 3~~

HISTORY OF GUN-TYPE BOMBS AND WARHEADS (u)

Mks 8, 10 and 11 (u) Title unclassified per Susan Stinchcomb 4/18/2002

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Information Research Division, 3434

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Mk 8 Exterior View

THE TX-8 BOMB

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(b)(1), (b)(3)

LENGTH—116 IN

DIAMETER—14.5 IN.

WEIGHT—3150 LBS

Mk 8 Cross Section

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12/8/50	TX-G Steering Committee appointed and holds initial meeting.
1/26/51	
	(b)(3)
3/15/51	
Early 1951	Externally carried TX-8 Bomb assigned nomenclature of TX-8 Prime.
10/51	TX-8 Prime program divided into two parts: TX-8-X1 (to cover carriage at subsonic speeds) and TX-8-X2 (a program to reduce drag in high-speed carriage).
11/51	Mk 8 Mod 0 achieves production.
1/52	Mk 8 Mod 0 enters stockpile.
4/1/52	(b)(3)
9/53	Mk 8 Bomb with Mk 8 Mod 1 Fuze (TX-8-X2) enters stockpile.
11/55	Mk 8 Mod 3 Bomb enters stockpile.
5/57	Mk 8 Bombs retired as Mk 11 enters stockpile.

<u>Mk 8 Warhead</u>

3/50	Gun-type warheads considered for missile application.
9/13/50	Santa Fe Operations Office requests that penetrating warheads be applied to guided missiles.
2/14/51	Santa Fe Operations Office authorizes design of XW-8/REGULUS.
1/18/52	XW-5/REGULUS program assigned priority over XW-8/REGULUS.
8/21/52	Field Command forwards proposed military characteristics for XW-8/REGULUS to Sandia.
9/24/53	Successful XW-8/REGULUS system test held.

8/54	Design of XW-8/REGULUS completed.
5/20/55	Program activity suspended.

TX-10 Weapon

5/6/48	Sandia Research and Development Board assigns priorities to weapon design projects.
1/21/49	Division of Military Application requests Bureau of Ordnance to study possible adaptation of Mk 8 as a light air-burst weapon.
4/22/49	Military Liaison Committee requests that study be restricted to a preliminary investigation.
3/8/50	Guided-missile symposium at Sandia Base proposes use of a lightweight gun-type device as a missile warhead.
7/6/50	Military Liaison Committee releases formal requirement for an air-burst, gun-type warhead.
8/9/50	Military Liaison Committee establishes formal requirement for a lightweight air-burst bomb.
8/17/50	Division of Military Application forwards characteristics for lightweight air-burst bombs.
9/6/50	Bureau of Ordnance, in reply to January 21, 1949 request of the Division of Military Application, offers to adapt the Mk 8 as a lightweight air-burst bomb.
10/3/50	Division of Military Application notifies Bureau of Ordnance that Sandia will develop the lightweight air-burst bomb.
10/18/50	Sandia Weapons Development Board discusses bomb and warhead applications. Santa Fe Operations Office subsequently authorizes deletion of warhead requirement. Bomb officially designated the TX-10.

4/1/55	Mk 11 design released.
1/1/56	Early production units of Mk 11 (Mk 91 Mod 0) become available.
7/1/56	Mk 91 Mod 0 enters stockpile.
8/56	

(b)(3)

History of Gun-Type Bombs and Warheads

Mk 8 Bomb

The gun method of assembling nuclear material, used in the wartime Little Boy design, was the first atomic weapon system to be devised, predating the establishment of the Los Alamos Laboratory. The method was nuclearly inefficient and was largely ignored for a time after the end of World War II, while interest centered on implosion techniques.

(b)(1), (b)(3)

At this time, the Los Alamos Scientific Laboratory was fully occupied in the above-mentioned study of improvements in implosion devices, and suggested that the task of developing a water-penetrating weapon (which probably would use gun techniques) could best be accomplished by a military group. No immediate action was taken on this suggestion, but the subject was briefly examined by the Z Division of Los Alamos in late 1946 and early 1947.

(b)(1), (b)(3)

The topic was subsequently discussed in a meeting of the Weapons Subcommittee of the AEC General Advisory Committee, and a decision made May 15, 1947 that consideration of a penetrating weapon be postponed.[4]

Meanwhile, however, the Military Liaison Committee had been discussing the general subject of subsurface atomic weapons. At the instigation of the Navy member, Rear Admiral William S. Parsons (who had armed the wartime gun-type Little Boy for

its historic drop on Hiroshima), Section ReM of the Navy's Bureau of Ordnance, prepared preliminary sketches of a penetrating gun device.

At about the same time, other groups were considering the same subject. The Joint Research and Development Board had established a Committee on Atomic Energy, and the subject of penetrating weapons was discussed in the October 2, 1947 meeting of this Committee. It was urged that serious consideration be given to the development of a gun-type device suitable for penetration use. Since the AEC weapon laboratories were already fully occupied with other high-priority work, the Committee recommended that the facilities of the Bureau of Ordnance be used.[5]

The Division of Military Application had also been considering the advisability of invoking the assistance of the military services in the development of penetrating weapons. Los Alamos had noted that gun systems were inherently inefficient, and expressed an opinion that the weapons laboratories should continue to concentrate on design of implosion devices.[6] Thus the Military Liaison Committee was requested to assign mechanical design of a gun-type penetration weapon to the Bureau of Ordnance.[7]

These several requests, all in the same vein, were presented for consideration to the Military Liaison Committee which, April 9, 1948, requested the Atomic Energy Commission to undertake development of a penetrating-type weapon, using the facilities of the Bureau of Ordnance.[8] This request was formally presented to the Bureau April 27, 1948, and accepted.[9] A code name of "Minnie" was initially assigned to the project, but was later found to have been used for a Bureau of Ships propulsion project and, in mid-July 1948, the name was changed to "LC" (a follow-on term to "LB," for the Little Boy), and which came to be commonly written as "Elsie."[10] That the Elsie program was considered a matter of some interest to the Military was indicated in a May 6, 1948 meeting of the Sandia Research and Development Board in which the project was assigned top priority, second only to the schedule for getting the Mk 4 Bomb into full-scale production.

The Bureau of Ordnance issued detailed work assignments. The Naval Ordnance Laboratory would be responsible for developing suitable pyrotechnic delay fuzes.

The Naval Ordnance Test Station would study external ballistics and design the tail. The Naval Powder Factory would investigate powder development. The Naval Ordnance Plant would handle much of the manufacturing and testing program, and when this location was subsequently closed, the work would be transferred to the Naval Proving Grounds and the Naval Gun Factory. Section ReM of the Bureau of Ordnance would provide overall design controls, including the task of guaranteeing survival of the nuclear assembly under impact conditions.

The development program would proceed in three overlapping phases. Feasibility and preliminary design studies would outline the most promising general design characteristics of the weapon, and these were scheduled for completion January 1, 1949. The second phase, covering experimental development and testing of prototype weapon design, would be completed a year later. The third phase, manufacture of prototype weapons, would be finished in another year, or January 1, 1951.

(b)(3)

The studies advanced rapidly and, by September 3, 1948, the Bureau of Ordnance could report that the design appeared feasible and that a weapon could probably be devised that would function satisfactorily after impact on water, and possibly after impact on hard surfaces which the weapon might encounter beneath the surface of the water.[11] It was initially felt that the fuze should be actuated at impact and have a delay of 1 to 2 minutes before bomb detonation, but it was later decided that a more reliable bomb would be created if the fuze action were initiated at time of release of the bomb from the carrying aircraft.

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The diameter of the bomb would be about 14 inches and the weight would be about 3000 pounds, as compared to 28 inches and 8900 pounds for the Little Boy. These reductions were due to the more compact nuclear assembly and a decrease in the thickness of the bomb case. The shape would be roughly cylindrical, with a flat nose for good penetration characteristics, and the bomb would attain a maximum impact velocity of 1500 feet per second. The minimum release altitude would be 500 feet, to give the bomb enough time during its fall to assume proper entry attitude, and there would be no restriction on maximum release altitude. It was felt that three separate and independent fuzes should be used, to provide adequate reliability. A meeting was held October 25 and 26, 1948, with Los Alamos assuming the task of developing impact-resistant initiators.[12]

An extensive series of tests was performed. The first group included 174 half-scale bombs of 6.25-inch diameter. These were fabricated in 49 different configurations, and were impacted against targets of steel and concrete at different angles, striking velocities, and missile temperatures ranging from -65°F to +165°F.

(b)(3)

Following the above, some 38 full-scale impact tests were conducted, to confirm the half-scale results. Interior ballistic tests were performed, to check the burning rate of various propellants and the behavior of the missile in the gun barrel. As fuze components became available, they were subjected to the shock produced by firing from a 14.25-inch-diameter railway gun.

Two series of wind-tunnel tests were held, one at the University of Minnesota to obtain aerodynamic coefficients of various tail configurations, and the other at the California Institute of Technology Cooperative Wind Tunnel to evaluate aerodynamic characteristics of five basic designs.

This paper was circulated for comment to Sandia and Los Alamos as well as the Military, and was subjected to a critical review.[23] The formal issue of the characteristics on November 10, 1950, however, retained the release speed requirement and noted that the bomb should function reliably when released at any altitude up to 50,000 feet and survive impacts on water, reinforced concrete, and--hopefully--thin steel plate.

(b)(3)

The November 22, 1950 meeting of the Sandia Weapons Development Board reviewed the overall gun-type weapons program, which now included the TX-9, TX-10, and TX-11, in addition to the TX-8. It was noted that the TX-8 was composed of three main parts: The nose, the tail, and the clamping ring which joined them. The bomb diameter had been fixed at 14.5 inches, its length at 116 inches, and its weight at 3260 pounds. The nose was a heavy forging with a blunt shape for water and ground entry, and contained the internal gun barrel, tamper, and projectile.

(b)(3)

A saddle on the external top of the bomb case contained switches and electrical connections to operate the primers.[25]

Sandia had proposed that an interlaboratory gun-type weapon coordination committee be established, similar in scope and authority to the TX-5 Steering Committee. Action was taken on this suggestion in late 1950, and the first meeting of this Gun Committee, with representation from Los Alamos and Sandia, was held December 8, 1950.[26] At this time, the TX-5 Steering Committee was renamed the TX-N Steering Committee to reflect its interest in all implosion weapons, and the new Gun Committee came to be known as the TX-G Steering Committee.

The first meeting of the TX-G Committee heard a report from Los Alamos concerning progress on design of an initiator for the TX-8. The initial design had been based on the device used in the Little Boy, and was then modified as design weaknesses were uncovered by the testing program. Some idea of the problems encountered were shown by the increasing impact requirements as the design progressed. The initial

assumption had been that the highest shock encountered in ground impact would be 7500 g's. This figure had progressively increased during design and was now 100,000 to 300,000 g's.

(b)(3)

Studies were meanwhile in progress on systems for nuclear safing.

(b)(3)

In early 1951 it was decided to identify the adaptation of the TX-8 for external carriage at subsonic speeds as the TX-8' (or TX-8 Prime) program. Plans were made to make only minor changes to the TX-8 and provide early, but only partial, satisfaction of the requirements for an externally carried TX-8. It was felt that, if this program could not be accomplished within a short time, it should be canceled in favor of the TX-11 Bomb, then being designed for external carriage on high-speed aircraft.

At this time, the AD4 and the F4U5 were the only carriers specified for the TX-8'. The AD4 was selected as the test aircraft, and Sandia issued a contract through the Bureau of Aeronautics to Douglas Aircraft Company to modify this aircraft for TX-8 carriage. Douglas designed a nose cap to reduce drag and help protect the TX-8' fuzing elements.

In late October 1951, the TX-8' program was divided into two parts; the TX-8-X1 and TX-8-X2. The X1 was the basic TX-8' program; the X2 was to provide a cleaner aerodynamic design and reduce the drag caused by the saddle. Inasmuch as 20 drops had already been made with the TX-8-X1, its compatibility and reliability were felt to have been proven, and attention was concentrated on the TX-8-X2 design.[33]

The T-28 saddle functions were replaced by a small box located in the aircraft fuselage. This allowed the use of a standard two-hook bomb rack and increased the clearance between the externally carried bomb and the ground. Fairings were installed over the side fuzes to reduce drag. Fuze tapes used for safing were pulled through the nose fairing to protect them from the windstream. A quick disconnect was installed, to permit the weapon to be dropped with tapes in place, thus leaving barriers in the path between the primer and the propellant, and preventing the fuzes from firing the main propellant charge.

This new device was called the T-31, and a subcontract was issued for its development. Due to the subsequent failure of the subcontractor to achieve a satisfactory T-31, Sandia produced a design having the T-31 located inside the bomb pylon, thus making it possible to detach the arming tapes from the pylon after bomb release, and prevent aircraft damage caused by whipping of the tapes in the slipstream. This work was undertaken November 5, 1951, and satisfactory hardware was being produced 10 days later.

The Mk 8 Mod 0 weapon was initially produced in November 1951 and was stockpiled in January 1952.

(b)(1), (b)(3)

The Military Liaison Committee, in a letter dated October 20, 1952, requested that the bomb be designed to withstand storage for 6-month periods under occasional temperature extremes of -80°F to +165°F, and flight bomb-bay temperatures of -90°F. It was pointed out that external bomb carriage might experience even more rigorous conditions of -100°F during a 12-hour flight, and that the 24-hour limitation regarding weapon assembly would be operationally troublesome.[40]

Inasmuch as the propellant characteristics were specified by the Bureau of Ordnance, the problem was referred to this organization.[41] It was noted that the environmental criteria had been specified after detail design of the Mk 8 had been essentially completed, and that these criteria differed considerably from the initial Mk 8 development objectives. It was also pointed out that any project to provide a propellant with improved temperature characteristics would duplicate work being undertaken in the TX-11 program. The Bureau of Ordnance subsequently allowed relaxation of the temperature limitations to 7 days at 130°F, 60 days at 120°F, and indefinitely at 110°F.[42] On March 12, 1953, the Military Liaison Committee agreed that major redesign efforts toward relieving temperature limits be directed toward the TX-11.[43]

The possibility of water leakage into the interior of the gun nuclear system had been a matter of early concern.

(b)(1), (b)(3)

When recovered, there was only about half a cup of water in the barrel, and this leakage was not felt great. Nevertheless, the Military, in the April 16, 1952 meeting of the Sandia Weapons Development Board, requested that the possible effects of this leakage on weapon performance be studied.[38]

Consequently, drops were made on a limestone bed in southwestern New Mexico. This rock possessed extremely high compressive strengths, from 18,000 to 23,000 pounds per square inch (average concrete strengths were about 4500 psi).

(b)(1), (b)(3)

Only one weapon showed any evidence of leakage. Experiments were started, using O-rings as replacements for the cork gaskets used to seal the openings in the bomb case.

It had been decided that the TX-8-X2 changes constituted a modification to the fuze rather than the bomb. Thus the Mk 8 Bomb with Mk 8 Mod 1 Fuze, incorporating a frangible nose and T-31 fuze tape control, was released for production and entered stockpile September 1953.

The TX-G Committee, whose functions had been largely assumed by the Special Weapons Development Board, was dissolved in January 1954. The Aspen Committee, which was directing Sandia-Los Alamos activities on the TX-11 weapon, agreed to handle any residual interlaboratory matters on the Mk 8 program.

(b)(3)

This change was made in the Mk 8 Mod 2 Bomb which was stockpiled in May 1955.

Meanwhile, studies had been made of the desirability of replacing the original Abner initiator with an improved design, the Phoebe. This change, plus the O-rings for sealing the bomb case, was known as the TX-8-X3 program during development.[44] Changes to the Atomic Energy Act permitted the Military to produce and stockpile certain atomic weapons parts, and it was suggested that the Bureau of Ordnance assume control of TX-8-X3 production work.[45] This proposal was rejected by the Atomic Energy Commission, which felt that close phasing was required, due to changes to both nuclear and nonnuclear portions of the Mk 8, and that Sandia should retain production control.[46] The Mk 8 Mod 3 was stockpiled in October 1955.

By February 1957, the Mk 11 Bomb was in production and entering stockpile. A decision was made to retire the Mk 8 weapons on a one-for-one basis as Mk 11's entered War Reserve. This retirement program started May 1957 and was completed 2 months later.

Mk 8 Warhead

The first consideration of a gun-type device for use with guided missiles was in a Los Alamos meeting of early March 1950, in which various missile programs were discussed.[47] Little immediate action was taken and, during the summer of that year,

attention was concentrated on developing the Elsie as a free-fall bomb to be released from aircraft. However, September 13, 1950, Santa Fe Operations Office requested Sandia and Los Alamos to consider the application of a penetrating warhead to various guided missiles. The missiles suggested were the HERMES A-3, HERMES C-1, REGULUS, RIGEL, and TRITON.[48]

It was obvious that a gun-type warhead would be more impact-resistant than an implosion design, and the request was referred to the Bureau of Ordnance, then doing work on the Mk 8 Bomb.

(b)(1), (b)(3)

Any missile usage would involve higher impact velocities and require new tests and additional design effort.[49] The Division of Military Application then referred the project to the Sandia Weapons Development Board, requesting that any Mk 8 Warhead developed be compatible with the above five missiles.[50]

Sandia made a preliminary study and, December 20, 1950, reported to the Santa Fe Operations Office that a firm estimate of the magnitude of the program could not be made. The terminal velocities of the missiles cited had not been definitely fixed, but were believed to be significantly greater than any previously considered in atomic-bomb design. Sandia proposed that a general investigation of impact warheads be continued, in an effort to delineate the most universally useful type of warhead and to outline a development program.[51]

The Santa Fe Operations Office suggested that initial application of the penetrating warhead be made to the REGULUS missile. This missile, scheduled for production in 1953, had a comparatively low impact velocity, and it was felt that a suitable warhead might be created by relatively simple modifications of existing components.[52] Sandia reported, January 23, 1951, that the development of such a warhead appeared feasible, and that the Bureau of Ordnance had been requested to investigate the effects of impact velocities and warhead mounting methods on the penetration characteristics of the Mk 8 device.[53]

The XW-8/REGULUS was authorized for design activity by the Santa Fe Operations Office February 14, 1951.[54] It was noted that since the REGULUS would attain an

impact velocity of only Mach 1.2, there would be few shock problems, unless the weapon were employed against extremely hard targets such as igneous rock or heavy armor plate.[55]

It was determined that the fuzing accuracy for the XW-8/REGULUS could be less than for an air-burst device, since the only requirement was to initiate a pyrotechnic delay train about one minute prior to impact. Should the weapon be launched from a submarine, a simple arming system would protect the submarine against premature detonations.

The Sandia Weapons Development Board discussed the Mk 8 missile-warhead program in its April 10, 1951 meeting. It was felt that current weapon capabilities would not allow impact velocities higher than Mach 2.5 without danger of breakup of the device. Since the terminal velocity of the HERMES was estimated to be Mach 4.5, it was obvious that radical changes to either warhead or missile would have to be made if this missile were used. It was apparent that either approach would require much design investigation, and it was decided to consider only the XW-8/REGULUS.[56]

It was found that the warhead compartment of the REGULUS was long enough to hold the basic Mk 8 Bomb assembly, but that little excess clearance was available, and that access to the nose of the weapon was difficult. Additionally, the center of gravity of the missile would be about 30 inches forward of its optimum location, and it was decided to delete the afterbody of the Mk 8. Tests were started to determine the terraballistics of the Mk 8 without its afterbody, and to ascertain whether the warhead would break away from the missile on impact with various surfaces.[57]

Another problem was the development of a mechanism to ignite the propellant of the internal gun device of the XW-8/REGULUS. In the drop bomb, this was accomplished by arming tapes, but the warhead application required either a device to pull the tapes at the proper point in the missile trajectory or a modification of the fuze.

yield would be the same as that of the Mk 8 Bomb. The warhead would function properly when subjected to missile impact speeds up to Mach 1.1 on water, earth, reinforced concrete and, if possible, harder targets. It would not broach or ricochet after impacts at angles between 60 and 90 degrees. The weapon would penetrate the target and detonate after coming to rest, and would be sufficiently watertight to function after water impact, followed by bottom impact.[64]

The Military Liaison Committee notified the Division of Military Application, October 3, 1952, that no requirement existed for design of penetration warheads capable of impact velocities higher than those of the REGULUS missile.[65]

Meanwhile, the Military decided that efficient use of the XW-8/REGULUS weapon required a high delivery accuracy. This was not possible with the existing missile system, and production requirements were deferred, awaiting refinement of the missile guidance system. Sandia was requested to complete its design work on the warhead, and the Navy was asked to proceed with scheduled flight tests.[66]

Successful component evaluation flights were conducted, and a successful warhead system test was held September 24, 1953. The Military Liaison Committee then suggested that, since there were few differences between the XW-8 Warhead and the extensively tested Mk 8 Bomb, further systems tests be held in abeyance.[67]

Design of the missile-warhead was completed in August 1954, and Report SC3483(TR), Status and Evaluation of the XW-8/REGULUS Warhead Installation at Design Release, was presented to the December 1, 1954 meeting of the Special Weapons Development Board.[68] The warhead was named the Mk 8 Mod 2, and production responsibility assigned to the Bureau of Ordnance.

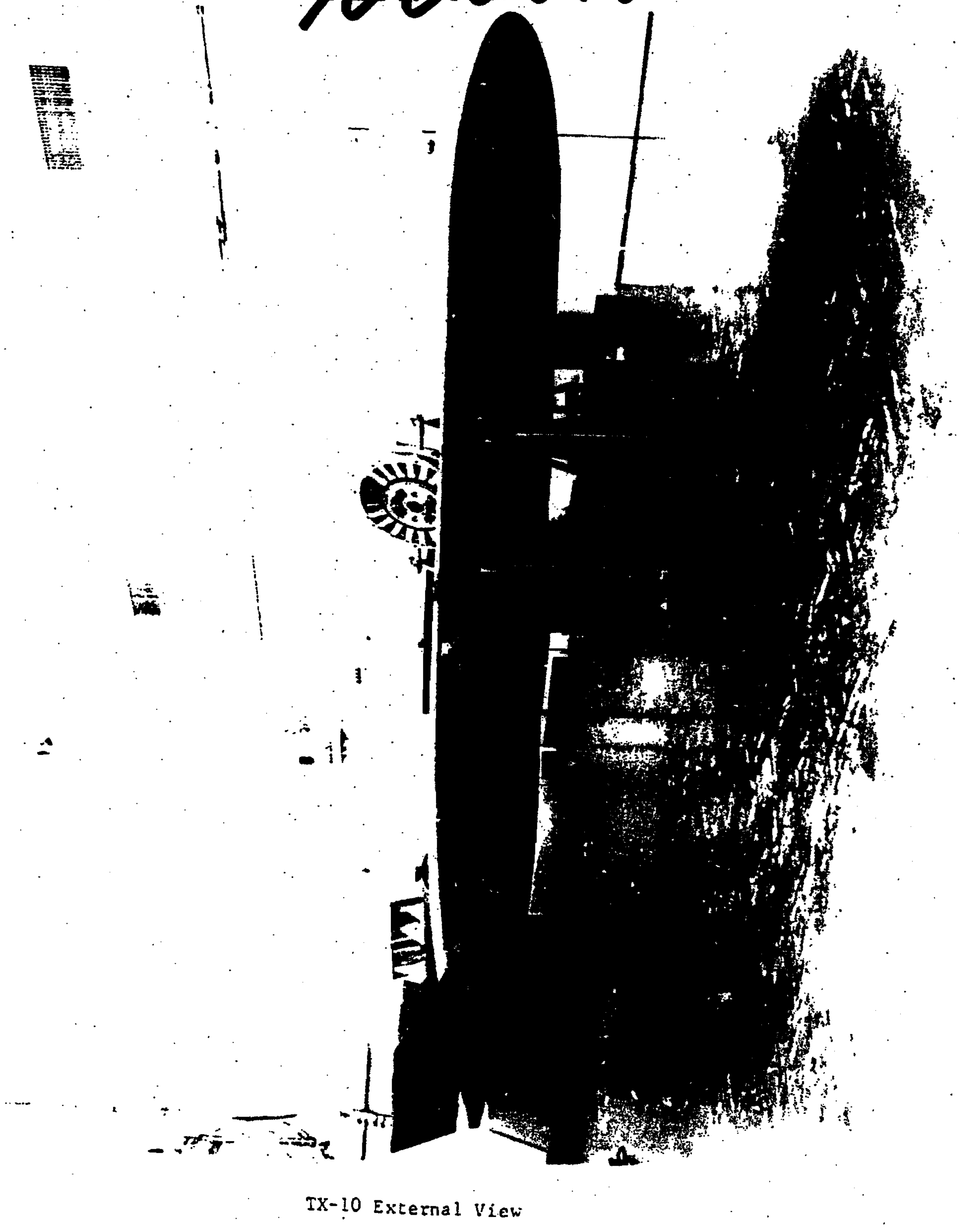
The warhead contained three delay fuzes, two located on the side and one on the nose.

(b)(3)

All requirements of the military characteristics were satisfied by the test program, although impact tests at less than 90 degrees were not conducted, and it was

not definitely determined whether the warhead would penetrate the target or break away on impact. However, Mk 8 Bomb tests had shown that satisfactory penetrations were achieved at entry angles as low as 30 degrees to the surface, and it was felt that the warhead would have similar satisfactory characteristics.

Subsequently, the possibility of developing a guidance system to effectively deliver the XW-8/REGULUS with pinpoint accuracy appeared remote. Consequently, on May 20, 1955, the Navy suspended activity in the program, together with work on the XW-11/REGULUS application.[69]



TX-10 External View

Subsequently, the Division of Military Application proposed that a lightweight, air-burst, gun-type missile warhead be developed,[74] and this suggestion received the backing of the Military Liaison Committee July 6, 1950.[75] It was proposed that Army Ordnance, then involved with the Mk 9 Shell, be requested to assist in design and development.[76]

Meanwhile, the lightweight, air-burst, gun-type bomb project had not been entirely forgotten, and the Military Liaison Committee, in a letter dated August 9, 1950, stated that the Joint Chiefs of Staff had established a requirement for the development of air-burst bombs sufficiently light in weight and small in cross section to be carried by high-speed tactical airplanes of the Air Force and Navy. It was felt that these bombs could be based on either implosion- or gun-type nuclear devices, and formal requests were made for both types.[77]

The subject was discussed in the August 16, 1950 meeting of the Sandia Weapons Development Board, with the Board agreeing to assume cognizance of the project. Two problems were immediately apparent: The development of a flexible fuzing system capable of attacking various tactical targets, and a weapon resistant to temperatures as low as -100°F.[78]

Sandia had meanwhile made a study of a lightweight bomb design and reported to AEC-Sandia August 17, 1950, that this could be produced by mid-1952. It was suggested that North American Aviation, Inc., be assigned the task of developing and manufacturing the outer case, internal support structures, and parts of the carrying pylon. Sandia would develop a fuzing and firing system, conduct drop tests, provide test and handling equipment, and act as project coordinator.[79]

On the same date, the Division of Military Application forwarded military characteristics for the above bomb. These required that the bomb be capable of tactical use by fighter, light bombardment, and attack (dive bomber) aircraft. The primary requirement was for external carriage, with alternate internal carriage being desired.

(b)(1), (b)(3)

The TX-G or Gun Committee agreed to accept interlaboratory responsibility for the TX-10.[26] The program was subjected to an intensive review in a Committee meeting of December 14, 1950, with the TX-10 being compared with the TX-7, an implosion design that had been pushed rapidly and which was now scheduled to enter stockpile earlier than the TX-10. It was felt by some conferees that the basic need for the TX-10 was eliminated by the advent of the TX-7. This latter weapon was larger than the proposed diameter of the TX-10 (27 inches versus 17 inches), but there appeared to be a sufficient variety of airplanes that could carry the TX-7.

(b)(1), (b)(3)

The problem was referred to the Sandia Weapons Development Board and discussed in a meeting December 20, 1950, with the Board being furnished copies of Sandia Report SC-1684(TR), A Critical Comparison Between the TX-7 and TX-10 Programs. This report noted that design was in work on a follow-on (and smaller) implosion device for the TX-7 (to be called the TX-12). The TX-12 would be less costly from the nuclear standpoint, would offer greater chances of increasing nuclear efficiency, and could be developed in about the same time scales. It was pointed out that work on the TX-10 would subtract effort from the TX-12, and that tactical use of the TX-10 (if manufactured in large numbers) would require major realignment of component production.

The Board noted that the TX-10 diameter would probably be smaller than the TX-7 or TX-12, but stated that further reductions in implosion-weapon diameter could be expected, as much nuclear design effort was currently being placed on implosion design improvements. After extensive discussion, the Board recommended that the TX-10 development be dropped in favor of the TX-12.[89]

The Division of Military Application wrote to Santa Fe Operations Office January 3, 1951, making reference to the above meeting. There were hopes that an interim TX-10 could be made available earlier than the TX-12, and it was suggested that the requirement for nuclear safing be eliminated and an external shape suitable for subsonic (but not necessarily supersonic) carriage be provided.[90]

The design status of the TX-10 was reviewed in the April 10, 1951 meeting of the Sandia Weapons Development Board. The bomb would be at least 17 inches in diameter and 2000 pounds in weight.

(b)(3), (b)(1)

The Board noted that the diameter and weight of the TX-10 exceeded the military characteristics, and that major reductions in these items could not be expected until the nuclear gun design was revised by Los Alamos.

(b)(3)

The project thus reverted to fundamental study of the problems of providing low burst heights, miniaturization, supersonic aerodynamics, and nuclear design improvements. Subsequently, the Military Liaison Committee canceled the TX-10 Bomb program May 7, 1952, noting that the Joint Chiefs of Staff had stated that a military requirement for the weapon no longer existed.

(b)(3)

(b)(1), (b)(3)

Mk 91 Mod 0 Bomb Cross Section

Mk 11 Weapon

The Mk 11 Bomb, a gun-type penetrating weapon to be externally carried on high-speed aircraft, had its early beginnings when the gun-type device was considered for guided-missile application in March 1950. In this usage nuclear safing would be required to protect the missile launching site, and it would be necessary for the warhead to survive high impact velocities.[47]

Subsequently, the Division of Military Application expressed interest in a gun-type bomb that could be nuclearly safed and externally carried on high-speed aircraft.[99] The external shape of the Mk 8 did not lend itself to such carriage (due chiefly to its blunt nose), and it was felt that any modification of the nose shape would be complicated by the existence of the nose fuze. A nose redesign would require a lengthy effort, and it was suggested that a development program be authorized for a Mk II Elsie for such usage.[100]

The Military Liaison Committee released a set of desired military and technical characteristics for impact, delayed-action atomic bombs April 17, 1950. These characteristics described a bomb which could be nuclearly safed during aircraft carriage and that would be suitable for release at speeds up to Mach 1.2.[54] Subsequently, July 31, 1950, the Division of Military Application requested the Bureau of Ordnance to design a Mk 8-type weapon meeting these characteristics, and offered Sandia assistance in the task of fitting the design to appropriate carrying aircraft.[101] This proposal was accepted by the Bureau of Ordnance,[102] and nomenclature of TX-11 was assigned to the project November 29, 1950.[103]

There were three main gun-weapon problems being studied at this time: The ballistics problem relating to external carriage and release at high speeds; the nuclear safing problem, which concerned missiles as well as bombs; and the problem of increasing the resistance of the weapon to impacts on hard targets, such as reinforced concrete, rock and armor plate.

The Naval Ordnance Laboratory started to design the TX-11 fuzing system. It was felt that feasibility and preliminary design studies to establish tentative characteristics could be completed by January 1, 1952; and that detailed design

toss, glide and dive bombing. It would be capable of carriage and release at speeds up to Mach 1.4 and altitudes of 50,000 feet. It would be able to function satisfactorily after impacts on water, soil, reinforced concrete, and--to the extent practicable--harder targets.

The Board noted that the characteristics required external carriage at both subsonic and supersonic speeds, but a shape designed for one of these velocities would not be optimum for the other. It was felt that the design should be based on the assumption that the least drag during the major portion of the flight was desirable. Inasmuch as jet fighters en route to a target cruised at subsonic speeds, the bomb shape should be designed to meet this requirement.

The desire that the weapon be capable of penetration into hard rock was of concern. It was difficult to suitably define "hard rock," and there was felt to be a low incidence of this type of terrain near any probable targets. The scheduled design-release date was established as October 1953, with the bomb to enter stockpile in January 1955.[34]

The Bureau of Ordnance had been conducting tests of a soft-steel nose cap which, it was hoped, would crush and absorb the shock of weapon impact. These tests were not encouraging, and it was eventually decided to provide a Fiberglas nose cap. When the bomb was to be carried in an internal bomb bay, this nose cap could be removed.

Wind-tunnel tests had meanwhile narrowed the choice of weapon length to two possibilities; 146 and 169 inches. The Bureau of Ordnance recommended that the shorter figure be selected: It caused less drag at subsonic speed, it was compatible with all aircraft being considered for carriage of the bomb, and it could be carried internally in all aircraft except the B-50 without removing the nose cap.[109]

Full-scale drops at Inyokern produced excellent results.

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No detonation of the high explosive occurred during any of the impacts. Tests of 6-1/4-inch-diameter scale models against reinforced concrete 10 feet thick demonstrated that impact velocities between 2000 and 2200 feet per second could be

absorbed.[110] As a result of these tests, the length of the TX-11 was frozen at 146 inches on June 30, 1952, and the fin size was established at two bomb diameters, or 28 inches.[111]

Meanwhile, work had been undertaken on the design of a nuclear safing system,

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The fuzes were mechanically armed and were of a pyrotechnic design similar to those used in the Mk 8.

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Glossary of Terms

Ad Hoc Working Group -- A group established by the Guided Missiles Committee to oversee the design of one particular missile-warhead installation.

Armed Forces Special Weapons Project -- An interdepartmental agency formed to handle military functions related to atomic weapons.

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Contact Fuze -- A fuze that detonates the weapon by contact with the ground or target.

Crossroads -- Full-scale tests of Mk III Bombs, held at the Pacific Proving Grounds. The Bikini Baker shot was held July 25, 1946. Much effects data were gained, and the shot was so destructive that a scheduled deep underwater burst was canceled.

Division of Military Application -- An AEC office that functions as liaison between the Military and weapons designers and producers.

Drag -- Resistance created by the passage of a shape through the air.

Field Command -- The local office of the Armed Forces Special Weapons Project, located on Sandia Base, Albuquerque, New Mexico.

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Joint Research and Development Board -- A Board established in mid-1946 as a postwar replacement for the Office of Scientific Research and Development. Its purpose was to suggest lines of research and development on military weapons and equipment.

Kiloton -- A means of measuring the yield of an atomic device by comparing its output with the effect of an explosion of TNT. A 1-kiloton yield is equivalent to the detonation effect of 1000 tons of high explosive.

Little Boy -- Code name for the gun-type weapon dropped on Hiroshima, Japan, August 6, 1945, during World War II. Originally called the Thin Man in reference to its long thin shape. The Thin Man was to use plutonium-239 as its nuclear material. Early samples of this isotope revealed that it contained small amounts of plutonium-240 which had a high preinitiation rate. A decision was then made to use uranium-235, allowing the length of the weapon to be radically reduced (due to the lower speed of assembly of the critical material). This change in outer shape was given the code name of Little Boy.

Los Alamos Scientific Laboratory -- A nuclear design organization located at Los Alamos, New Mexico. Called the Los Alamos Laboratory during World War II.

Mach -- A measure of speed. Mach 1.0 is the speed of sound, or 738 miles per hour at sea level.

Manhattan Engineer District -- A District of the Army Engineers established in August 1942 to provide the facilities that would be needed for design and construction of the atomic bomb.

Military Characteristics -- The attributes of a weapon that are desired by the Military.

Military Liaison Committee -- A Department of Defense committee established by the Atomic Energy Act to advise and consult with the AEC on all matters relating to military applications of atomic energy.

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Naval Ordnance Laboratory -- A portion of the Bureau of Ordnance devoted to design and test of Naval ordnance.

Neutron -- An uncharged particle of slightly greater mass than the proton.

Operation Crossroads -- See Crossroads.

Pitch -- Motion of the bomb as it falls through the air, such that the nose and tail alternately rise and fall.

Proton -- The nucleus of the atom of the light isotope of hydrogen. It has a unit positive charge of electricity.

Prototype -- An early weapon type, generally hand-produced before a production run.

Pylon -- A strut to hold bomb in position below an airplane wing.

Pyrotechnic Fuze -- A fuze that operates by burning or detonation of a small charge of explosive.

Radar -- Named for Radio Detecting and Ranging. Radars emit a pulse of high-frequency energy and measure the time lapse from that transmission to receipt of a reflected electrical "echo" from an object. This time measurement determines the distance of the object from the transmitting antenna of the radar.

Ricochet -- A glancing rebound of a missile when it strikes a target.

Safing -- Putting a weapon in condition such that it cannot fire.

Salton Sea Test Base -- Located on the site of a Naval Auxiliary Air Station on the shores of Salton Sea, California. One of the early sites for ballistic tests of atomic bombs.

Sandia Research and Development Board -- A joint Sandia-Military board formed March 2, 1948, at Sandia Base to provide local guidance on weapons design.

Uranium-238 -- A radioactive element, atomic number 92. Natural uranium contains about 99.3-percent of uranium-238; the rest is uranium-235.

Z Division -- A division of the Los Alamos Scientific Laboratory, elements of which moved to Sandia Base and became the nucleus of Sandia Laboratory and Corporation.

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